



ES 401 Rutland Energy Project



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Middlebury College Spring 2014

The City of Rutland and GMP, through our unique relationship and partnership, are committed to demonstrating to the State and the country how energy innovation can transform both our environment and our local economy. We will be a model and serve as a laboratory for sustainability that can be replicated on a much larger scale."

- Mayor Christopher Louras

Introduction and Narrative:

Today, Rutland has already come to be known as the "solar capital" of Vermont. Part of Green Mountain Power's (GMP) goal is to change the public's perspective of Rutland, and they have been successful so far. For example, the utility has already invested in the Energy Innovation Center in downtown Rutland and helped recruit more businesses into Rutland. With GMP's help, 3 new solar and energy companies have opened in downtown. Twelve additional businesses have also opened indirectly due to GMP's presence in downtown Rutland. GMP's solar projects are also helping Rutland's rebranding. Many of these solar projects are being developed on brownfields, landfills, and other sites that are otherwise of little value to the city. Now, these commercial sized solar projects are helping the city gain tax revenue and energy. As a result, Vermonters are also thinking of Rutland differently. Rutland's short term goal is to build 10 MW of solar by the end of 2015. However, Rutland's long term goal is to become Vermont's, or perhaps New England's, model for a sustainable city.

This goal, however, is not easy. One of the biggest obstacles that Steve Costello, Vice President for Generation and Energy Innovation at GMP, cites is communication. Communication with the whole city about GMP's initiatives and projects to gain public support is very important to the continuation and growth of GMP's contribution to Rutland. With so many means of communication today and how differently people get their information, Costello states that at times it can be hard to build relationships with the community. That being said, whether it is holding community events in the city or educational events for the public, GMP is always striving to improve their relationship with the community.

One project that GMP is working on to bolster their relationship with the community includes their pilot program for improving streetlights. Their goal is to change all streetlights to LED lights. While there is an upfront cost for the installation and purchasing of bulbs, the benefits to Rutland include a reduced environmental footprint and lower energy bills in the long run. There are many benefits to using LED lighting. For example, it casts better quality light and is much more energy efficient. The

project, which is being piloted in Rutland's Northwest neighborhood, also entails installing light sensors that can provide data for GMP to see if the light is working or not. By having these sensors send data, GMP can also reduce the amount of time that streets are without light—an added community benefit on top of the environmental and economic ones.

GMP is also working on the Baxter Street project in Rutland to improve home energy efficiency measures, thereby reducing homeowner energy bills and furthering customer's quality of life. These measures include installing highly efficient heat pumps, which can provide a more comfortable living condition than oil-based heating. Other measures include insulation, EnergyStar rated appliances, solar panels, and duct sealing. GMP is also using this pilot project to gain a better understanding of different technologies that may or may not have value together to a larger customer base. GMP is planning on analyzing how much energy will be saved and how much carbon emissions are abated after tracking performance data for a year.

The development of GMP's Energy Innovation Center is a story in and of itself. The space not only allows for an exhibition area for the public to learn more about GMP's innovative energy initiatives, but also provides office space for collaborative work between GMP's innovation team, Efficiency Vermont, and Neighborworks. Efficiency Vermont and Neighborworks are both non-profit organizations striving to help promote sustainable energy usage in Vermont. This makes the Energy Innovation Center Rutland's sustainable energy hub.

But what makes GMP—a profit-maximizing firm in the volatile energy market—such a unique, unconventional, and innovative utility company? Costello says it is partly because of GMP's CEO, Mary Powell, who is “always looking for the next big thing,” her inspirational mentality “drives a lot of us” Costello mentioned. Another part of it is that GMP is a small enough company that it can make decisions more quickly and take more risks, giving the company an advantage and the edge over conventional utility companies.

Background and Purpose:

Solar energy has been gaining a lot of attention, especially as Rutland tries to pursue its goal of becoming the “solar capital” of Vermont. However, energy efficiency has long been the most cost effective way of reducing energy, and is considered a necessary step to take before pursuing renewable energy. After talking with Green Mountain Power and Mayor Louras, we realized how much potential there was for reducing energy consumption through energy efficiency upgrades. We wanted to quantify and show to the public that massive potential. Through empirical research, we also wanted to identify important stakeholders who have the responsibilities to facilitate this sustainability initiative in Rutland and help connect with the community. Through this, we can also help Rutland build upon its renewable energy goal of 10,000 kW (10 MW) by 2015.

Our project is a synthesis and analysis of small and large-scale energy saving measures in the town of Rutland. Working with Green Mountain Power (GMP) and Efficiency Vermont, we collected average electricity consumption data for Rutland as well as the energy saving potential of common home energy upgrades. Utilizing these data, we conducted two related analyses: citywide energy consumption maps and a home efficiency cost curve. This provides two representations of the same dynamic, one on an individual scale and the other encompassing an entire community. Our hope was to create complimentary visualizations to encourage the citizens of Rutland to consider the environmental and economic benefits that energy efficiency upgrades can create. Our guiding research questions included:

- What is the current state of energy usage in Rutland?
- What are the potentials for energy efficiency measures in Rutland?
- How can we reach those potentials?
- What roles can different corporate stakeholders, as well as community members, take to advance Rutland's energy sustainability goal?

Process and Methodology:

Cost Curve:

We adopted a McKinsey-style cost curve analysis to create a visual representation of the array of energy saving options available to homeowners in Vermont (Figure 1; Enkvist et al., 2007). Using upfront and installation costs provided by Efficiency Vermont, we researched energy savings figures, CO₂ abatement statistics, as well as calculated monetary savings over certain periods of time. The resulting energy and money saving figures were aggregated to create our own cost curve representing common home energy upgrades. Based on our findings, customers—as well as other interested individuals—can get a better sense of which energy savings measures deliver the most savings per dollar of initial investment. The use of a visual aid adds tangibility to the data that may not otherwise be easily understood in spreadsheet format. The investments that yield negative costs over the given time period have the highest return on investment since they will pay for themselves in savings before the time period is up. We hope that seeing the monetary and energy saving benefits of these upgrades will motivate people to explore the range of options that they have to reduce their energy bill and minimize their overall footprint on the environment.

Energy Consumption Map:

The culmination of our analysis was the residential energy consumption heat map we created based on representative average data from Green Mountain Power for the City of Rutland. This map showed energy consumption averaged by census block (to protect customer anonymity) to display the average and range of energy consumption throughout the various communities within Rutland. Our initial map represented this standard energy consumption dynamic on an average day in Rutland (Figure 2). With the integration of the data from which we created the cost curve, we were able to extrapolate what the energy consumption picture of Rutland would be like if everyone were able to implement

these efficiency measures (Figure 3). We calculated the average energy savings for an individual household after the upgrades have been installed and applied it to the entirety of the city. The change in total energy consumption was immediately apparent on the heat map and the actual data were even more impressive.

The dramatic change based on the implementation of these relatively inexpensive and easy upgrades we hope will serve as a community-wide call to action to investigate and hopefully invest in these efficiency measures. They are not only financially beneficial for individuals, but can have a much larger impact on the community level, something we hope our visuals will demonstrate and publicize.

Findings and Results:

Rutland City Energy Efficiency Upgrade Cost Curve - 2034

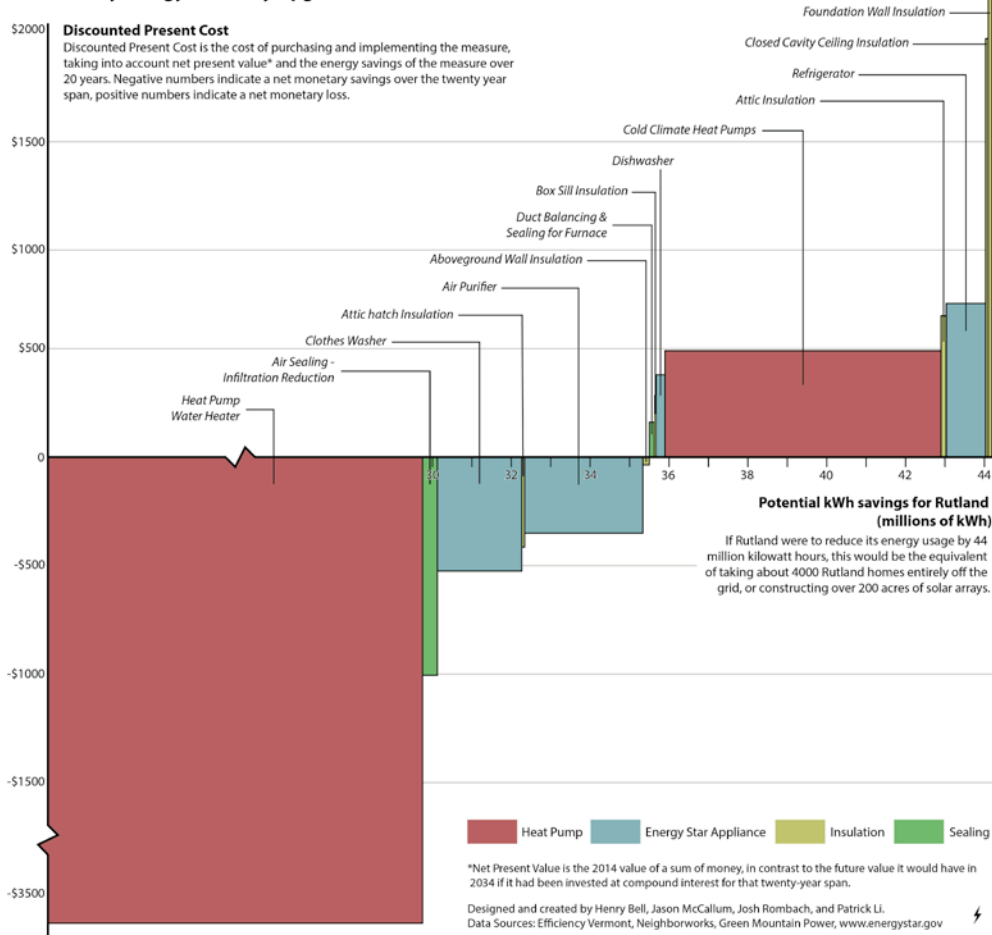


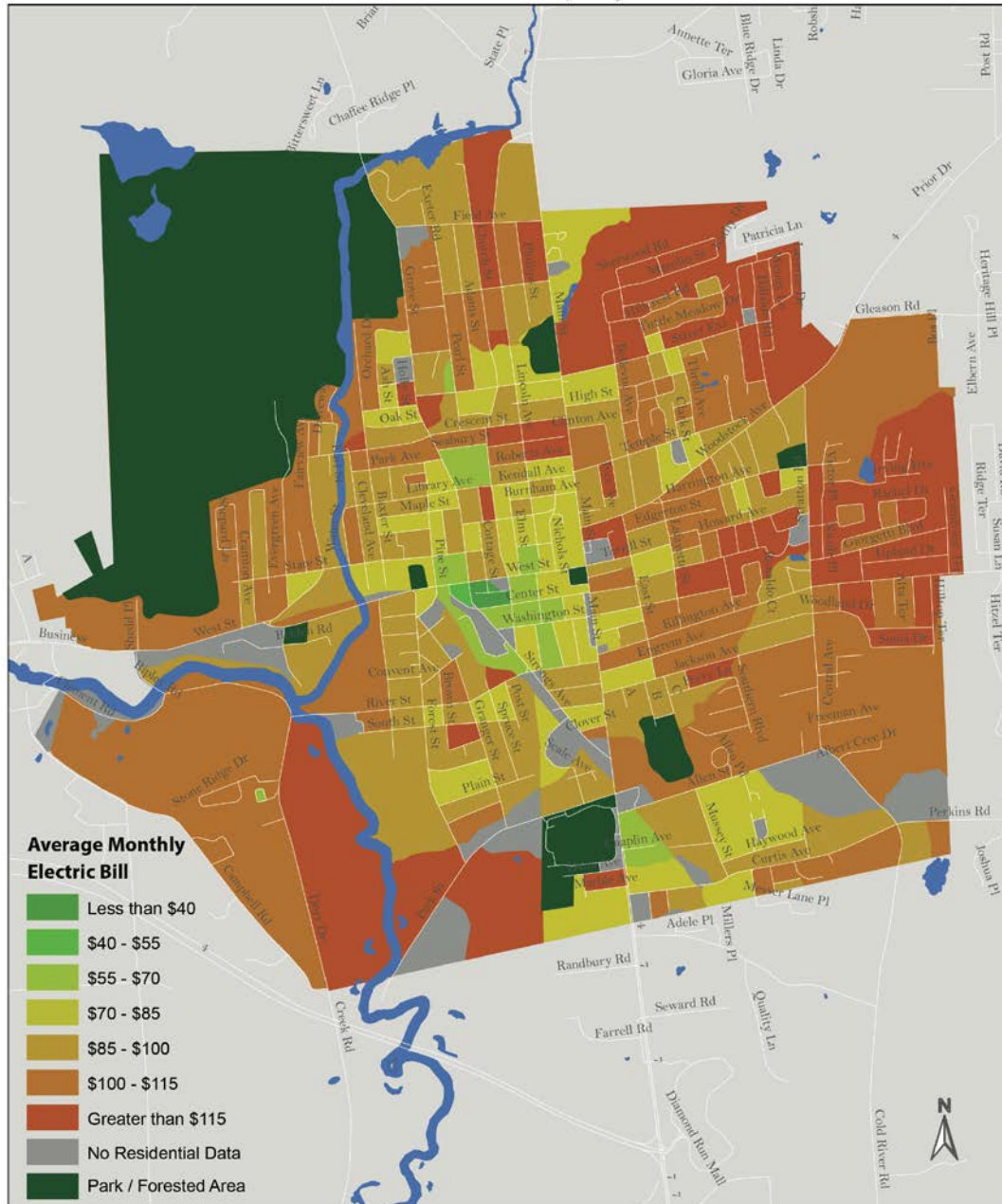
Table 1: List of energy efficiency measures researched in this study. For more details on potential savings, discounted present cost, and kWh savings, see the cost curve above.

Energy Efficiency Measures	Potential Saved (kWh savings for all households in Rutland)	Discounted Present Cost (\$)	kWh saving costs (\$/kWh saved)	Abatement cost (\$/ lbs CO2 saved)	Average Installation Cost (\$)
Heat pumps					
Heat pump water heater:	\$29,708,775	-\$3,803.5415	-\$0.0497	-\$90.3883	\$2,200.00
Cold climate heat pumps (cooling):	\$7,168,941	\$480.5093	\$0.0260	\$47.3408	\$2,000.00
Energy Star appliances					
Energy Star clothes washer:	\$2,205,828	-\$532.9430	-\$0.0938	-\$121.9549	\$400.00
Energy Star refrigerator:	\$994,176	\$691.2680	\$0.2700	\$350.8974	\$1,000.00
Energy Star dishwasher	\$201,942	\$345.6340	\$0.6647	\$606.3754	\$500.00
Air purifier	\$3,036,897	-\$331.7498	-\$0.0424	-\$55.1996	\$200.00
Insulation					
Attic hatch insulation:	\$62,136	-\$414.8312	-\$2.5927	\$110.9884	\$1,750.00
Above ground wall insulation:	\$155,340	-\$19.1308	-\$0.0478	-\$2.1715	\$1,600.00
Attic insulation:	\$108,738	\$645.9523	\$2.3070	\$110.9884	\$1,750.00
Box sill insulation:	\$23,301	\$288.4108	\$4.8068	\$196.1978	\$550.00
Foundation wall insulation:	\$85,437	\$2,607.3532	\$11.8516	\$531.0292	\$3,600.00
Closed cavity ceiling insulation:	\$46,602	\$1,918.0703	\$15.9839	\$734.8928	\$2,500.00
Building Enclosure					
Air sealing - infiltration reduction:	\$225,243	-\$1,005.2466	-\$1.7332	-\$80.2272	\$1,250.00
Duct balancing & sealing for furnace:	\$100,971	\$133.7236	\$0.5143	\$31.0264	\$1,100.00

(All data from Efficiency Vermont, Neighborworks, and Energystar.gov)

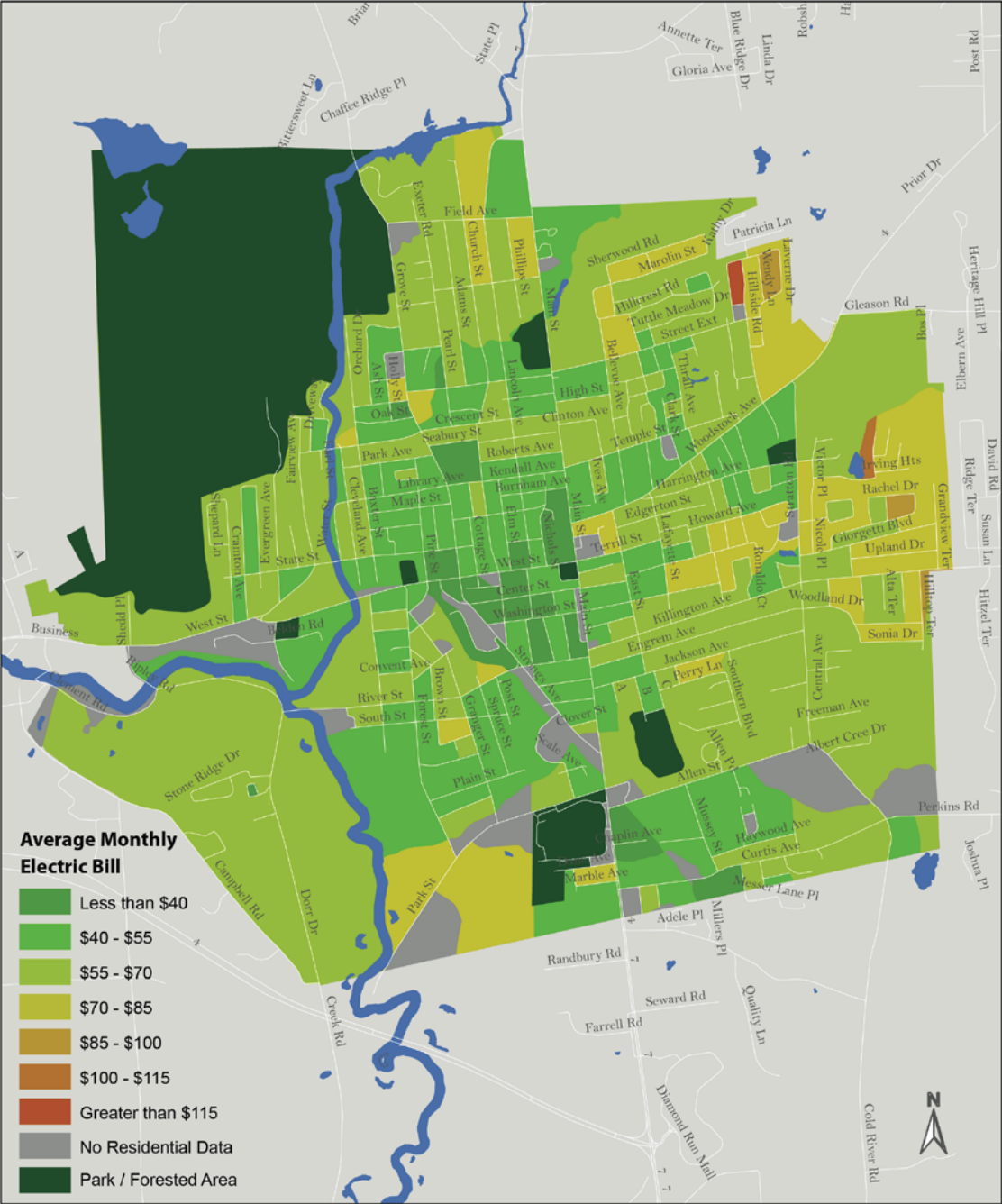
Rutland Residential Electric Bill - Current

This map displays the amount that Rutland residents pay for their household electric bills, averaged by city block. The data is based upon total kWh usage for an average day in October, as well as the electric service rate that Green Mountain Power currently charges all of their residential customers.



Rutland Residential Electric Bill - Potential

This map displays the amount that Rutland residents would pay for their household electric bills if they implemented all of the efficiency upgrades. Prices are averaged by city block. The data is based upon total kWh usage for an average day in October, as well as the electric service rate that Green Mountain Power currently charges all of their residential customers.



Interviewing Process:

To really bring our project together, we conducted a number of interviews with our community partners and other locals to get a better sense of what energy efficiency means to them as companies and individuals. Throughout our time working with GMP and Efficiency Vermont, we were able to sit down with some of their employees and get their personal views on sustainability and efficiency in their own homes and communities. The passion with which they spoke about sustainability as well as their communities really demonstrated the strong link between these ideas and how each can promote the other. Those individuals we emailed that were not associated with our community partners told us similar stories about responsibility to themselves, their families, and their local community. This relationship between personal decisions and their effects on others and the environment continually arose as a unifying theme throughout our interviews as well as our project in general.

Notable Quotes:

“The utility industry is a really traditional, slow-moving, old school business...The phone industry never thought the mobile phone would take off, and dozens of phone companies went out of business because they weren’t forward looking. They always thought their traditional model would be there and obviously it wasn’t. The ones that are still around were branching out into different forms of communications. When we’re talking about solar at Green Mountain Power, its not just about developing solar, it’s about what is our future going to be? At some point our current model is going to be dead, and I don’t think most utilities believe that yet, or are willing to admit it to themselves. Most utilities are doing everything they can to protect the traditional model. We are absolutely looking for ways that we can add value for our customers through a different model, and still have a business when this is all over.”

-Steve Costello (VP of GMP Energy Innovation Center)

“We’re looking for models to add to and build on the old fashioned utilities model”

- Steve Costello

“When it comes to investments, [home efficiency upgrades] are a really good one in terms of the return on investment. You’re doing something to your home to improve it, and at the same time you’re saving money, its an all around good direction to go in.”

- Jeff Manney (Project Manager, Efficiency Vermont)

If people want to spend some money on improving their home, they really need to prioritize energy efficiency because that is an improvement that is also going to save you money. When you save money on your fuel bills, you can take that money and put it towards the other improvements you want to make.”

- Jeff Manney

Conclusion:

From our research, we discovered the massive potentials for implementing energy efficiency measures in Rutland. We would need to develop over 200 acres of solar farms to provide the amount of energy saved through efficiency measures. That would be around 35 MW of solar capacity. Just for reference, the largest commercial solar farm in Vermont is around 20 acres—a 2.5 MW solar farm on Route 7. It would take 13 similarly sized commercial solar farms to produce the energy that would equate to the amount saved through efficiency measures. The cost curve illustrates the cost effectiveness and the kWh saving potential for each energy efficiency upgrade. Realizing this potential and facilitating this sustainability initiative will take a range of stakeholders: individuals, businesses, and most importantly, the community.

A Home Owner's Guide to Energy Efficiency Measures, and Other Sustainability Upgrades

This following research looks at three categories of energy efficiency measures and sustainability upgrades for residential owners: energy, health, and water.

In McKinsey and Company's "global cost curve for greenhouse gas abatement measures", energy efficiency measures are reported as a significant opportunity for carbon abatement in the building sector at a negative cost (Enkvist et al., 2007). The report suggests that energy efficiency measures, such as building insulation, lighting systems, air-conditioning, and water heating are significant opportunities for carbon mitigation. The energy measures also have a great business case. This research studies upgrade measures related to insulation, envelope infiltration, duct leakage, HVAC equipment sizing, selection, and efficiency, appliances, and performance of building enclosure.

- **Insulation:** A more insulated and airtight building has less moisture and airflow related issues. Low insulation levels in a section of a building can lead to comfort issues. Standard installation of insulation results in significant gaps in the thermal envelope, which may lead to major energy losses. Moisture condensation in building cavities may also potentially cause catastrophic structural issues.
- **Envelope infiltration:** Air leaks can cause drafts, which lead to comfort issues, increased heating and cooling costs, and increased indoor air pollutants. In multifamily units, air leakages between units increase odor, pet dander, second hand smoke, and sound transfer from one unit to another. Increased stack effect due to air leakage also causes top floors to be significantly hotter than bottom floors
- **Ducts:** Ducts that are not sealed properly can lead to comfort issues because air is not distributed properly, leading to significant temperature differences throughout the building and higher heating and cooling costs. Significant duct leakage can also exacerbate envelope infiltration through pressurization and depressurization spaces.
- **HVAC equipment sizing, selection, and design:** Studies have found that at least 80% of heating and cooling systems in residential construction are oversized, which causes short cycling. This results in reduced equipment lifespan, higher energy bills, and in the summer, significantly decreased dehumidification resulting in high interior humidity levels which increases the risk of mold and decreases comfort levels.
- **HVAC equipment efficiency:** Heating and cooling can account for up to 60% of a household's energy use. Energy savings of 20% to 30% can be achieved by installing space heating and cooling equipment with the ENERGY STAR label.

- **Lighting:** Both exterior and interior lighting accounts for about 5% to 15% of a new home's total energy use. High efficiency lighting appliances, such as fixtures that are ENERGY STAR qualified, can have savings of 75% or more. That is equivalent approximately \$14 a fixture annually on the average energy bill.
- **High efficiency appliances:** The US Energy Information Agency reports that energy consumption from appliances and electronics have been increasing. Appliances account for approximately 20% to 30% of a home's total energy use and about 25% of a home's indoor water use. Therefore, having efficient appliances can significantly conserve both energy and water use. ENERGY STAR qualified appliances use approximately 10% to 50% less energy and water than standard models (ENERGY STAR, 2013).
- **Performance of building enclosure:** A well designed and properly installed building enclosure can minimize water intrusion into homes. Controlling rain and ground water is vital for preventing mold growth, which may lead to human health issues, comfort issues, and premature durability failures.

Human health and well-being are also other incentives for implementing sustainability measures/ upgrades.

- **Whole building mechanical ventilation:** People today spend more time indoors with windows and doors closed. Homes with insufficient outdoor air tend to have comfort and health related issues such as increased humidity, odors, and pollutants. A well designed whole building mechanical ventilation system can mitigate that risk significantly.
- **Ducted kitchen and bathroom ventilation to the outdoors:** Potential pollutants and considerable moisture and odor produced from kitchens and bathrooms should be controlled at the source. Proper ventilation better indoor environment quality of households, leading to increased levels of comfort and health.
- **Combustion appliances, CO alarms:** Combustion appliances that are indoors with no ventilation requirements can cause poor indoor air quality and may be significantly harmful to residents, especially in homes that are well constructed and well-sealed. Closed combustion through direct or power venting can dramatically mitigate the risk.
- **Radon-resistant construction:** The EPA estimates that radon is the number one cause of lung cancer among non-smokers. The World Health Organization also states that most radon-induced lung cancers occur in people's homes (WHO, 2013). Therefore, radon-resistant construction techniques should be encouraged, especially in areas that are designated as high-risk zones for radon.
- **Garage pollutant protection:** Car emissions, such as carbon monoxide, may adversely affect occupants' health. These emissions can easily leak from the garage into occupied spaces of the home and cause detrimental health effects for

occupants. Locating HVAC equipment in the garage can exacerbate the effect by pulling polluted garage air into the system and distributing it throughout the home.

- **Filters:** Air filters that are properly installed can dramatically improve indoor air quality and therefore, health and comfort levels by removing unwanted and potentially harmful particles from the supply air stream.
- **Formaldehyde:** Formaldehyde is a by-product of combustion and certain other natural processes. It is a common chemical used to manufacture numerous building materials and household products. Formaldehyde may have adverse health effects, and high concentrations may cause asthma attacks and cancer (EPA, 2013).
- **Paints:** Many paints give off volatile organic compounds that may worsen indoor air quality and may cause adverse health effects (EPA, 2013b).

References

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